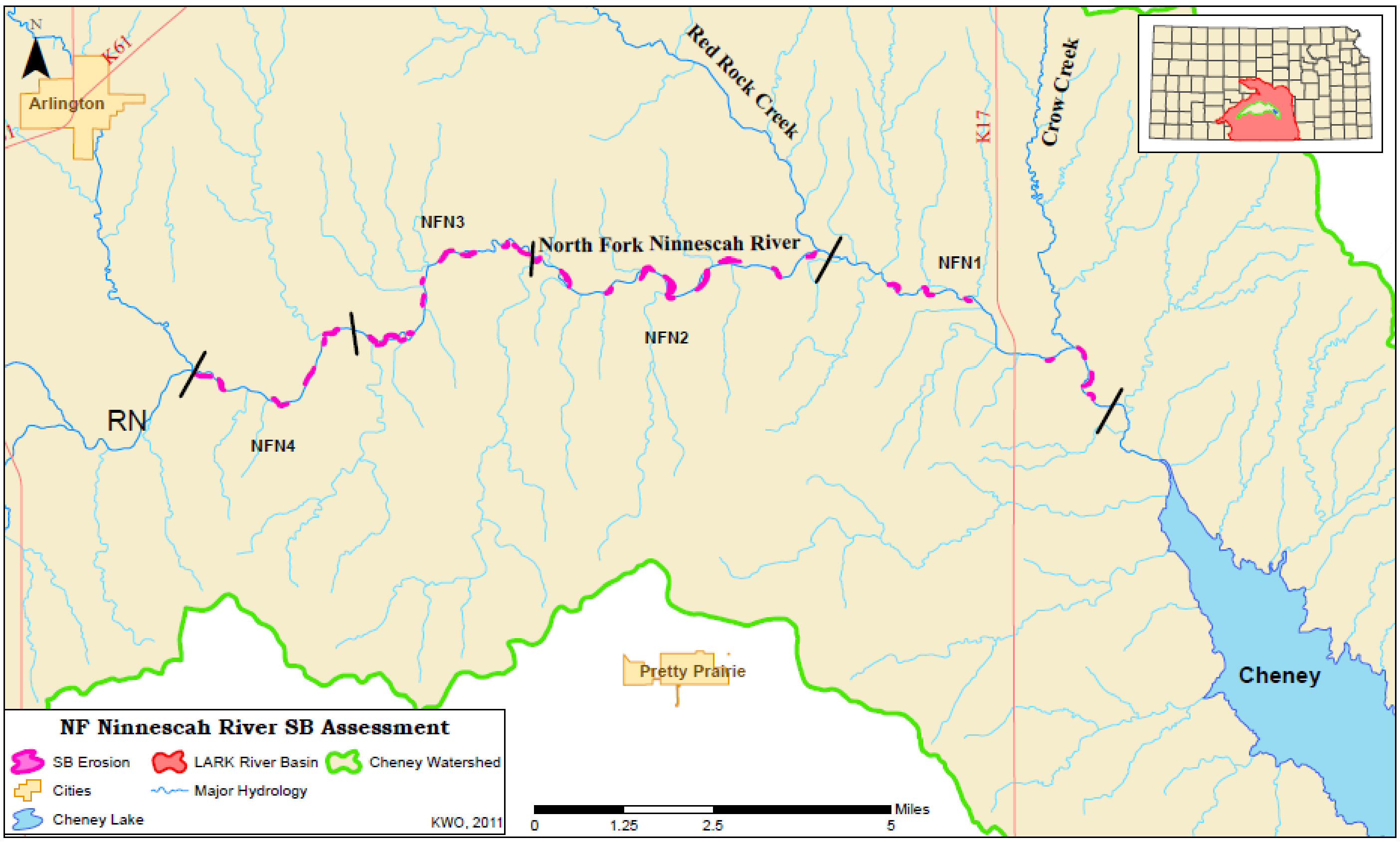
# MAINSTEM NORTH FORK NINNESCAH RIVER STREAMBANK EROSION ASSESSMENT

ArcGIS® Comparison Study: 1991 vs. 2008 Aerial Photography

**DRAFT: June 2011**

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## Executive Summary

Federal reservoirs are an important source of water supply in Kansas for approximately two-thirds of Kansas' citizens. The ability of a reservoir to store water over time is diminished as the capacity is reduced through sedimentation. In some cases reservoirs are filling with sediment faster than anticipated. Whether sediment is filling the reservoir on or ahead of schedule, it is beneficial to take efforts to reduce sedimentation to extend the life of the reservoir.

The Kansas Water Authority has established a *Reservoir Sustainability Initiative* that seeks to integrate all aspects of reservoir input, operations and outputs into an operational plan for each reservoir to ensure water supply storage availability long into the future. Reduction of sediment input is part of this initiative.

The Mainstem North Fork Ninnescah River Assessment, an ArcGIS® Comparison Study, was initiated to partially implement the *Reservoir Sustainability Initiative*. This assessment identifies areas of streambank erosion to provide a better understanding of portions of the Cheney Lake Watershed for streambank restoration purposes and to increase understanding of streambank erosion to reduce excessive sedimentation in reservoirs across Kansas. The comparison study was designed to guide prioritization of streambank restoration by identifying reaches where erosion is most severe on the mainstem North Fork Ninnescah River.

The Kansas Water Office (KWO) 2011 assessment quantifies annual tons of sediment eroding from the mainstem North Fork Ninnescah River over a 17 year period between 1991 and 2008. A total of 41 streambank erosion sites were identified, covering 33,336 feet of unstable streambank and transporting 34,740 tons of sediment downstream per year. This sediment accounts for roughly 35 acre-feet per year of sediment transport downstream and possibly loading into Cheney Lake. Note that the identified streambank erosion sites are only a portion of all streambank erosion occurrences in the watershed. Only those streambank erosion sites covering an area 1,500 sq. feet, or more, were identified. Any erosion that covers an area smaller than roughly 1,500 sq feet incurs a high margin of error making calculations unreliable. Streambank erosion sites were analyzed by four identified stream reaches and three 12-digit Hydrologic Unit Codes (HUC12). The assessment results concluded that a majority of the identified eroded sediment in the watershed has been transported annually from the mainstem North Fork Ninnescah River reach two (NFN2) and North Fork Ninnescah River reach three (NFN3); at roughly 17,927 and 7,640 tons annually, respectively. These identified reaches account for an estimated 74 percent ($1.5 million) of the total stabilization cost estimates on the mainstem North Fork Ninnescah River. Results by HUC12 indicated that HUC 11030014303 as the most active of the three HUC12s for tons of sediment erosion, 20,897 tons of sediment per year. This HUC12 also accounted for 14,960 feet of unstable streambank and 42 percent ($1.07 million) of total stabilization cost estimates. The total stabilization cost estimated for the mainstem North Fork Ninnescah River by conducting streambank stabilization practices for all identified sites would cost approximately $2.5 million. Stabilization cost estimates were based on the average stabilization costs, at $71.50 per linear foot, as reported in the TWI *Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment*.

The KWO completed this assessment for the Cheney Lake Watershed Restoration and Protection Strategy (WRAPS) Stakeholder Leadership Team (SLT). Information contained in this assessment can be used by the Cheney Lake Watershed WRAPS SLT to target streambank stabilization and riparian restoration efforts toward high priority stream reaches or HUC12s along the mainstem North Fork Ninnescah River. Similar assessments are ongoing in selected watersheds above reservoirs throughout Kansas and are available on the KWO website at [www.kwo.org](http://www.kwo.org), or may be made available upon request to agencies and interested parties for the benefit of streambank and riparian restoration projects.

## Introduction

Wetlands and riparian areas are vital components of proper watershed function that, when wisely managed in context of a watershed system, can moderate and reduce sediment input. There is growing evidence that a substantial source of sediment in streams in many areas of the country is generated from stream channels and edge of field gullies (Balch, 2007).

Streambank erosion is a natural process that contributes a large portion of annual sediment yield, but acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, land loss, habitat loss and other adverse effects. Many land use activities can affect and lead to accelerated bank erosion (EPA, 2008). In most Kansas watersheds, this natural process has been accelerated due to changes in land cover and the modification of stream channels to accommodate agricultural, urban and other land uses.

A naturally stable stream has the ability, over time, to transport the water and sediment of its watershed in such a manner that the stream maintains its dimension, pattern and profile without significant aggregation or degradation (Rosgen, 1997). Streams significantly impacted by land use changes in their watersheds, or by modifications to streambeds and banks, go through an evolutionary process to regain a more stable condition. This process generally involves a sequence of incision (downcutting), widening and re-stabilizing of the stream. Many streams in Kansas are incised (SCC, 1999).

Streambank erosion is often a symptom of a larger, more complex problem requiring solutions that may involve more than just streambank stabilization (EPA, 2008). It is important to analyze watershed conditions and understand the evolutionary tendencies of a stream when considering stream stabilization measures. Efforts to restore and re-stabilize streams should allow the stream to speed up the process of regaining natural stability along the evolutionary sequence (Rosgen, 1997). A watershed-based approach to developing stream stabilization plans can accommodate the comprehensive review and implementation.

Additional research in Kansas documents the effectiveness of forested riparian areas on bank stabilization and sediment trapping (Geyer, 2003; Brinson, 1981; Freeman, 1996; Huggins, 1994). Vegetative cover based on rooting characteristics can mitigate erosion by protecting banks from fluvial entrainment and collapse by providing internal bank strength. Riparian vegetative type is an important tool that provides indicators of erosion occurrence from land use practices. The Riparian area is the interface between land and a river or stream. Riparian areas are significant in soil ecology, environmental management and because of their role in soil conservation, habitat biodiversity and the influence they have on aquatic ecosystems overall health. Forested riparian areas are superior to grassland in holding bank stabilization during high flows, when most sediment is transported. When riparian vegetation is changed from woody species to annual grasses and/or forbs, sub-surface internal strength is weakened, causing acceleration of mass wasting processes (extensive sedimentation due to sub-surface instability) (EPA, 2008). The primary threats to wetlands and forested riparian areas are agricultural production and suburban/urban development.

Reservoirs are a vital source of water supply, provide recreational opportunities, support diverse aquatic habitat, and provide flood protection throughout Kansas. Excessive sediment can alter the aesthetic qualities of reservoirs and affect their water quality and useful life (Christensen, 2000). Sediment deposition in reservoirs can be attributed to many factors, including precipitation, topography, contributing-drainage area of the watershed and differing soil types. Decreases in reservoir storage capacity from sediment deposition can affect reservoir allocations used for flood control, drinking-water supplies, recreation and wildlife habitat. Land use has considerable effect on sediment loading in a reservoir. Intense agricultural use in the watershed, with limited or ineffective erosion prevention methods, can contribute large loads of sediment along with constituents (such as phosphorus) to downstream reservoirs (Mau, 2001).

In Kansas, monitoring the extent of erosion losses is difficult, and current up-to-date inventories are needed. This assessment identifies areas with erosion concerns and estimates erosion losses to provide a better understanding of this watershed for mitigation purposes and for application of understanding to watersheds across Kansas.

**Study Area**

The mainstem North Fork Ninnescah lies within the Cheney Lake Watershed, which covers 633,000 acres, 933 sq-miles, which drain into Cheney Lake via the North Fork Ninnescah River (Figure 1). Cheney Lake was constructed at the lower east end of the North Fork Ninnescah River between 1962 and 1965 by the Bureau of Reclamation, with a 100 year design life for sediment storage The North Fork Ninnescah River is the major source of inflow to Cheney Lake, contributing 70 percent of the water flowing into the Lake. The lake currently supplies 60 to 70 percent of Wichita's daily water supply (Christensen, 2006). The reservoir is both federally and state authorized to providing a reliable municipal water supply system for the City of Wichita, wildlife habitat, recreational opportunities and downstream flood control. The original conservation-pool storage of the lake was roughly 152,000 acre-ft, with an additional flood-control capacity of about 81,000 acre-ft.

In 2008, USGS performed a bathymetric survey of Cheney Reservoir to determine total sediment volume deposited in the reservoir from 1965 to 1998. The survey determined that roughly 7,100 acre-ft of sediment has been deposited into Cheney Reservoir over the 34 year period at a rate of 209 acre-ft/yr, filling 27% of the inactive conservation storage pool since dam closure. Results also indicated that 11 percent of the deposited sediment mass was located in the submerged river channel and that about 89 percent of the sediment mass was located in the out-of-channel area (Mau, 2001).

Cheney Lake watershed encompasses land in five counties including Sedgwick, Reno, Kingman, Pratt and Stafford, with the majority in Reno County. Six 12-digit hydrologic unit codes (HUC12s) lay within the Cheney Lake watershed and three cover the study area of the mainstem North Fork Ninnescah River (Figure 2). Land use is predominantly agricultural (greater than 98 percent) with crop production accounting for roughly 72% of the land use in the Cheney Lake Watershed. Crops produced include corn, grain sorghum, soybeans and wheat (KSU, 2008). While cropland is predominant, pasture and rangeland make up roughly 20% of the watershed, concentrated along streams and rivers in the floodplains (Figure 3). Conservation Reserve Program (CRP) makes up 15% and forest only 2% of land use; found using a GIS land-use database developed in 1997 by the Natural Resource Conservation Service (NRCS). Topography in the Cheney Lake watershed ranges from flat to gently sloping hills.

Soils in the Cheney Reservoir watershed generally are classified as clayey loam on the uplands to sand or sandy loam on low-lying areas or where slopes are less than 3 percent. Many of the soils in the watershed are subject to erosion by wind and rainfall runoff (Rockers and others, 1966). The Kanza-Ninnescah is the predominant soil series along the study area of the mainstem North Fork Ninnescah River. Kanza soils are loamy fine sand with 1 to 12% clay and are very deep, poorly drained and somewhat poorly drained soils found on flood plains in the Great Bend Sand Plains. Slopes range from 0 to 2 percent with mean annual precipitation at 28 inches and a mean annual temperature at 57 degrees F. Kanza soils formed in alluvium and permeability is rapid above the water table. The Ninnescah Series consists of very deep, poorly drained, moderately rapidly permeable soils that formed in loamy alluvium. These soils are predominantly fine sandy loams with 10 to 17% clay and are found on flood plains in river valleys of the Great Bend Sand Plains with a mean precipitation at 29 inches and mean annual temperature at 56 degrees F (NRCS, 2005).

**Figure 1: Cheney Lake Watershed Assessment Area**

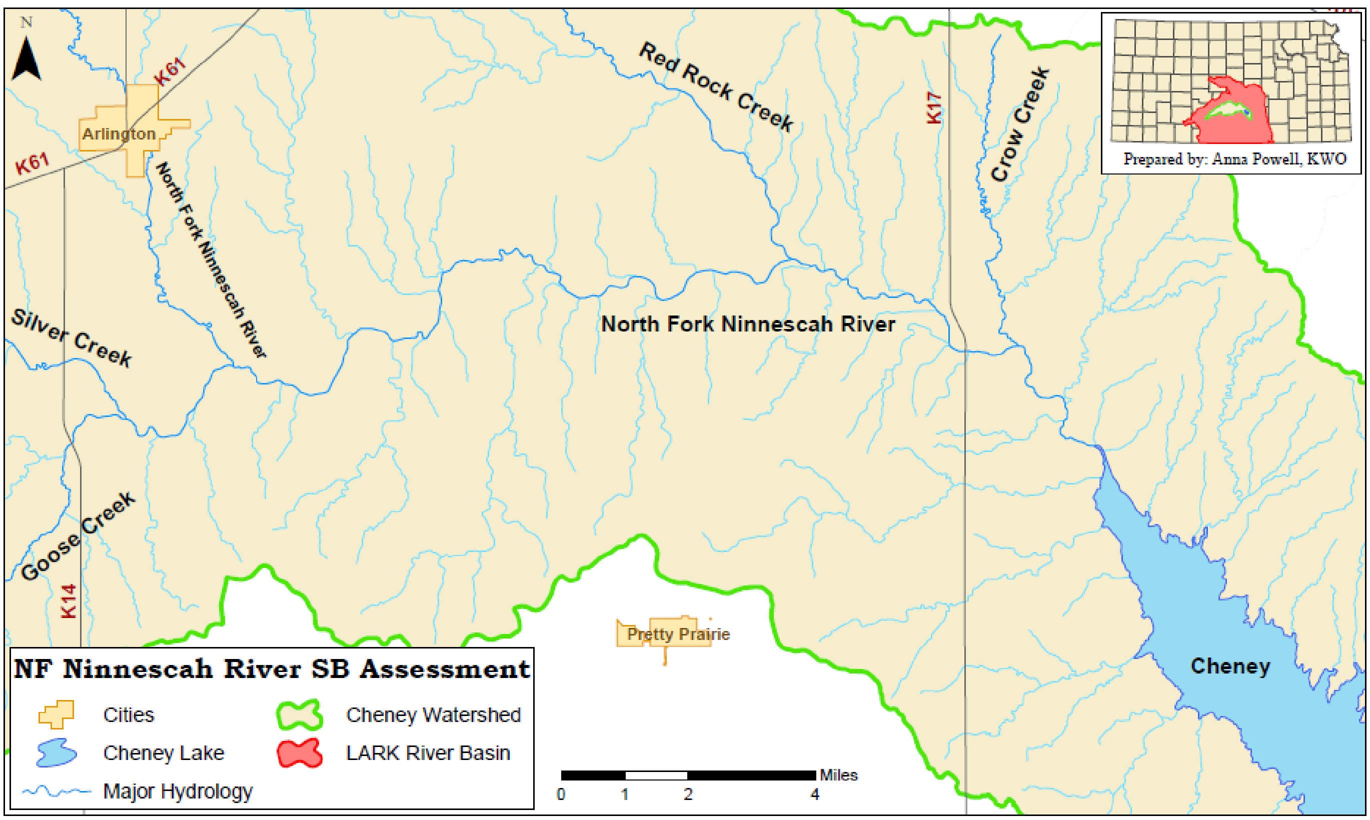


**Figure 2: Cheney Lake Watershed Assessment Area HUC12s**

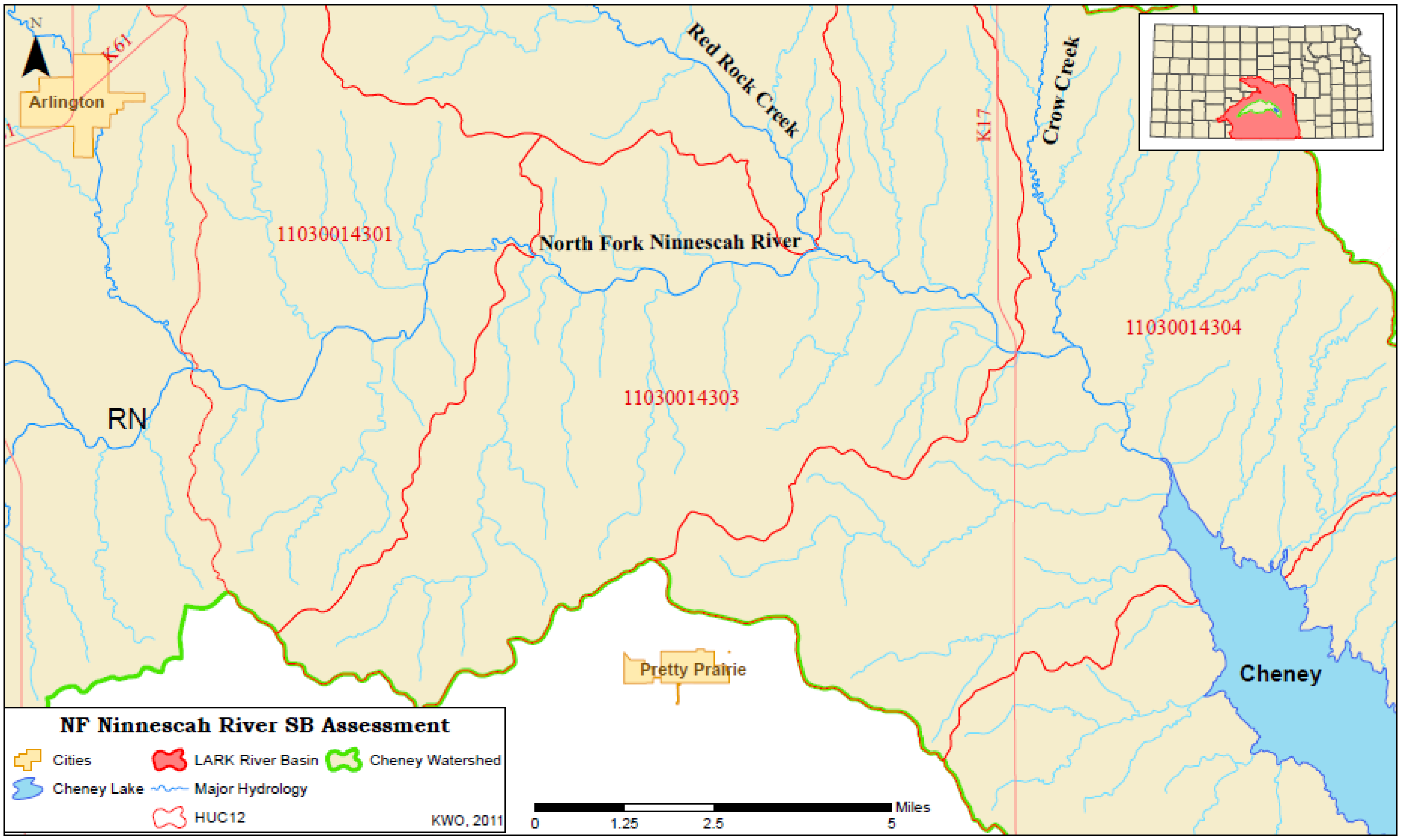
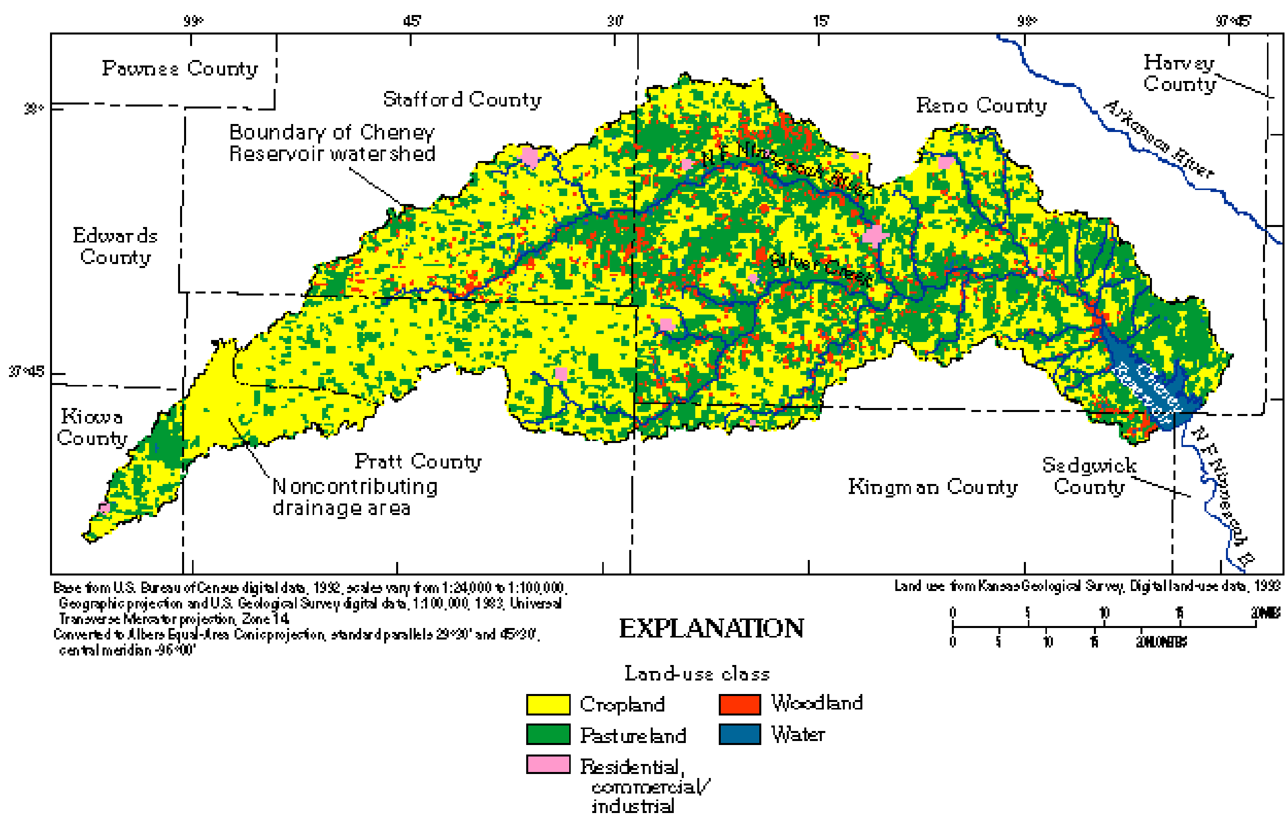



**Figure 3: Land Use in the Cheney Lake Watershed, 1993**



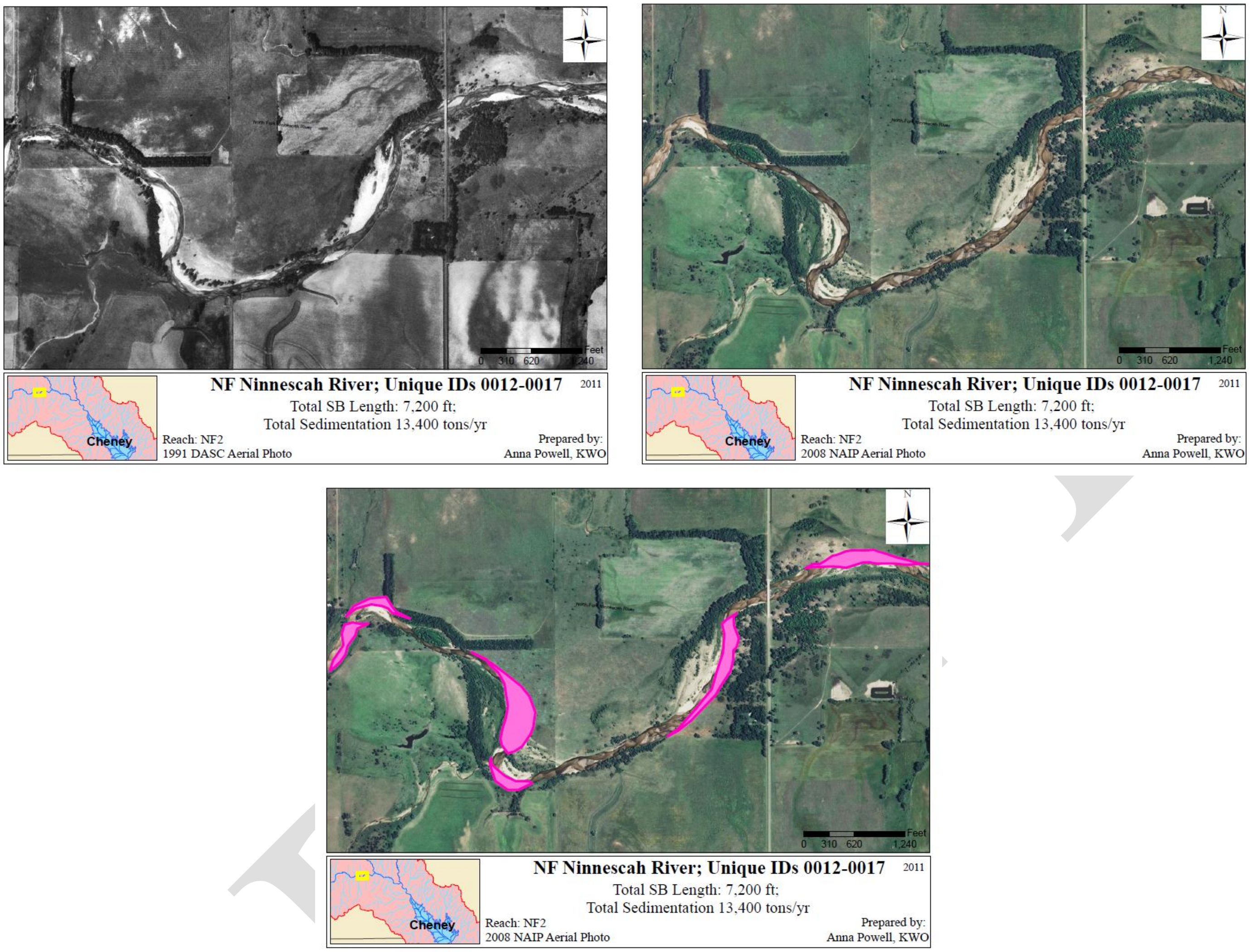
**Data Collection Methodology**

The Mainstem North Fork Ninnescah River streambank erosion assessment was performed using ArcGIS® ArcMap® 10 software. The purpose of the assessment is to identify locations of streambank instability to prioritize restoration needs and slow sedimentation rates on the mainstem North Fork Ninnescah River. ArcMap® 10, an ArcGIS® geospatial processing program, was utilized to assess color aerial photography from 2008, provided by National Agriculture Imagery Program (NAIP), and compare it with 1991 black and white aerial photography, provided by the State of Kansas GIS Data Access & Support Center (DASC).

The streambank erosion assessment was performed by overlaying 2008 NAIP county aerial imagery onto 1991 DASC county aerial imagery (Figure 4). Using ArcMap® tools, "aggressive movement" of the streambank between 1991DASC and 2008 NAIP aerial photos were identified, at a 1:6,000 scale, as a site of streambank erosion. "Aggressive movement" represents areas of 1,500 sq. feet or more of streambank movement between 1991 DASC and 2008 NAIP aerial photos. Note that the identified streambank erosion sites are only a portion of all streambank erosion occurrences along the mainstem North Fork Ninnescah River. Any erosion that covers an area smaller than roughly 1,500 sq. feet, incurs a high enough margin of error, making calculations unreliable. This error can be attributed to some distortions between years when aerial photos are taken and digitally georepherencing, and due to shading attributed to leafing of trees in aerial photos when photos are taken in spring, summer and early fall months. Leafing can affect the ability to find the exact location of streambanks.

Streambank erosion sites were denoted by geographic polygons features "drawn" into the ArcGIS® software program using ArcMap® editor tools. The polygon features were created by sketching vertices following the 2008 streambank and closing the sketch by following the 1991 streambank, at a 1:2,500 scale. Data provided, based on geographic polygon sites include: watershed location, unique ID, stream name, type of stream and type of riparian vegetation.

**Figure 4: 1991 DASC & 2008 NAIP Aerial Photos with Identified Streambank Erosion Sites**




The streambank erosion assessment data also includes estimates of the average volume of soil loss, in tons per year, eroded from streambank erosion sites. Estimation of average soil loss is performed utilizing the identified erosion site polygon features and calculating perimeter, area and streambank length into a regression equation. Perimeter and area were calculated through the *field calculator* application within the ArcGIS® software. Streambank length of identified erosion sites were computed through the application of a regression equation, formulated by the KWO office. This equation was developed by taking data from the *Enhanced Riparian Area/Stream Channel Assessment for John Redmond Feasibility Study*, a report prepared by The Watershed Institute (TWI) and Gulf South Research Corporation (GSCR), and relating the erosion area (in sq. feet) and perimeter length of that erosion area (in feet) to the unstable stream bank length (in feet). The multiple regression formula of that fit (R-square = .999) is:

**Estimated SB Length** = ([Area_SqFt]*-.00067) + ([Perimtr_ft]*.5089609)

The intercept of the model was forced to zero.

Average volume of soil loss was estimated by first calculating the volume of sediment loss and applying a bulk density estimate to that volume for the typical soil type of the mainstem North Fork Ninnescah River. The volume of sediment was found by multiplying bank height, surface area lost over the 17 year period between the 1991 and 2008 and soil bulk density. This calculated volume is then divided by the 17 year period to get the average rate of soil loss in mass/year:

**Average Soil Loss Rate (Tons/yr) =**

[Area_SqFt]*[BankHgtFt]*SoilDensity(lbs/ft$^3$)/2000(lbs/ton)/([NAIP_ComparisonPhotoYear]-[BaseAerialPhotoYear])

Soil Bulk Density, used in the average soil loss rate equation, was calculated by first determining the moist bulk density of the predominant soil in the study area, using the USDA Web Soil Survey website. The predominant soil type along the North Fork Ninnescah River was Kanza-Ninnescah sandy loams, frequently flooded, with an average moist bulk density at 1.6 g/cc. This moist bulk density estimate was then converted into pounds per cubic foot and reduced by 15% to get a dry bulk density estimate at 85 lbs/ft$^3$. This dry bulk density is then compared to the dry bulk density on a soil texture triangle, at 10% clay and 70% sandy-loam, as a second comparative estimate, at roughly 1.57 g/cc or 84 lbs/ft$^3$. Based on the two methods, 85 lbs/ft$^3$ was used for the typical bulk density of the predominant soil type along the mainstem North Fork Ninnescah River above Cheney Lake, and used in the average soil loss rate equation.

Streambank height measurements, also used in the average soil loss rate equation, were obtained from a USDA-Natural Resources Conservation Service assessment, *Cheney Lake Streambank Erosion Report*, with the help of Cheney Lake WRAPS Coordinator and KWA member. Streambank height measurements in the report were performed in several locations in the upper and lower end of the North Fork Ninnescah River upstream of Cheney Reservoir and downstream of the Silver Creek/North Fork Ninnescah River fork. These field verified streambank height measurements were the basis for extrapolating streambank height measurements for the identified streambank erosion sites for this assessment.

**Analysis**

To accommodate streambank rehabilitation project focus, the mainstem North Fork Ninnescah study area was delineated into four stream reaches and three 12-digit Hydrologic Unit Codes. Stream reach sections include: NFN1, NFN2, NFN3 and NFN4 (Figure 5). Stream reach sections were titled by the stream name and in numerical order from downstream to upstream. The three 12-digit Hydrologic Unit Codes (HUC12s) include 11030014303, 11030014303 and 11030014301 (Figure 6). Streambank erosion sites were analyzed for: streambank length (in feet) of the eroded bank; annual soil loss (in tons/year); percent of streambank length with poor riparian condition (riparian area identified as having cropland or grass/crop riparian vegetation); estimated sediment reduction through the implementation of streambank stabilization Best Management Practices (BMPs) at an 85% efficiency rate; and streambank stabilization cost estimates for eroded streambank sites. Streambank stabilization costs were derived from an average cost to implement streambank stabilization BMPs, as reported in the TWI *Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment*; at $71.50 per linear foot (Figure 7). Streambank stabilization costs may vary based on soil type and materials used for streambank stabilization BMPs and may differ from the estimates developed for the *Kansas*

*River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment* BMP estimates. Due to the lack of sufficient information to accurately develop streambank stabilization average costs in this area, TWI estimates were used.

**Figure 5: Mainstem North Fork Ninnescah River Streambank Assessment by Stream Reach**

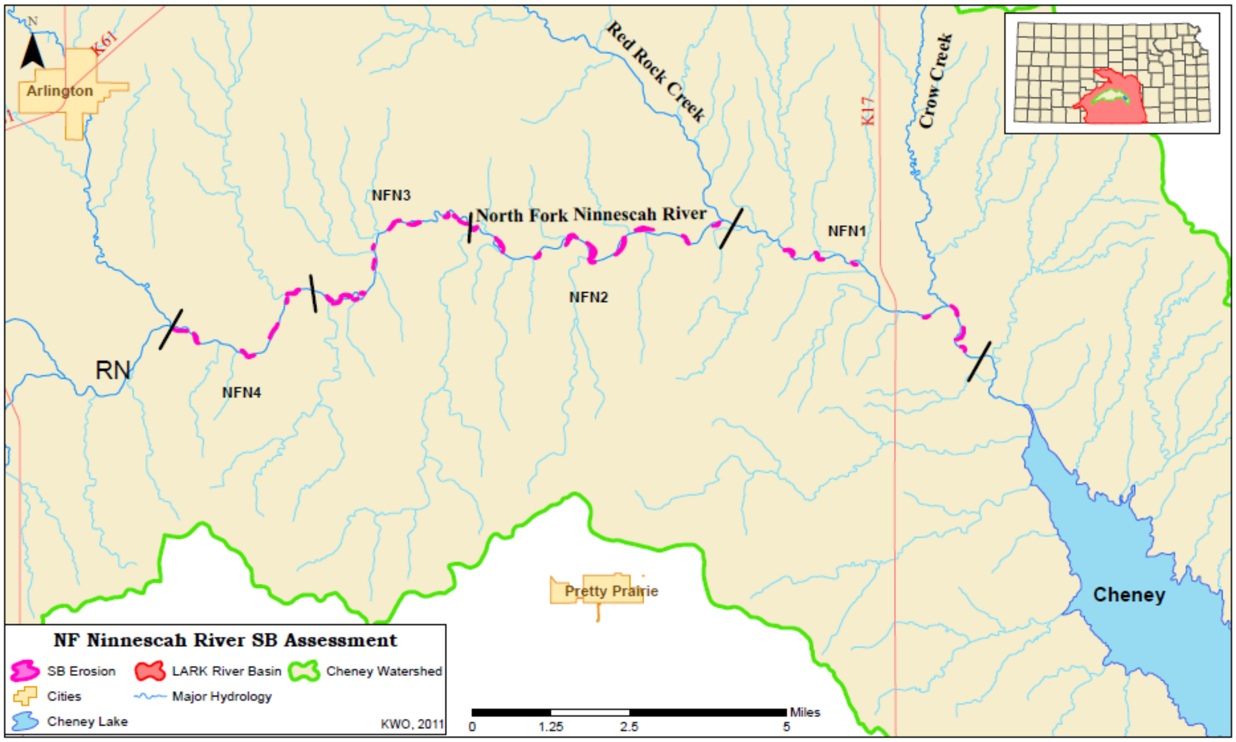



**Figure 6: Mainstem North Fork Ninnescah River Streambank Assessment by HUC12**

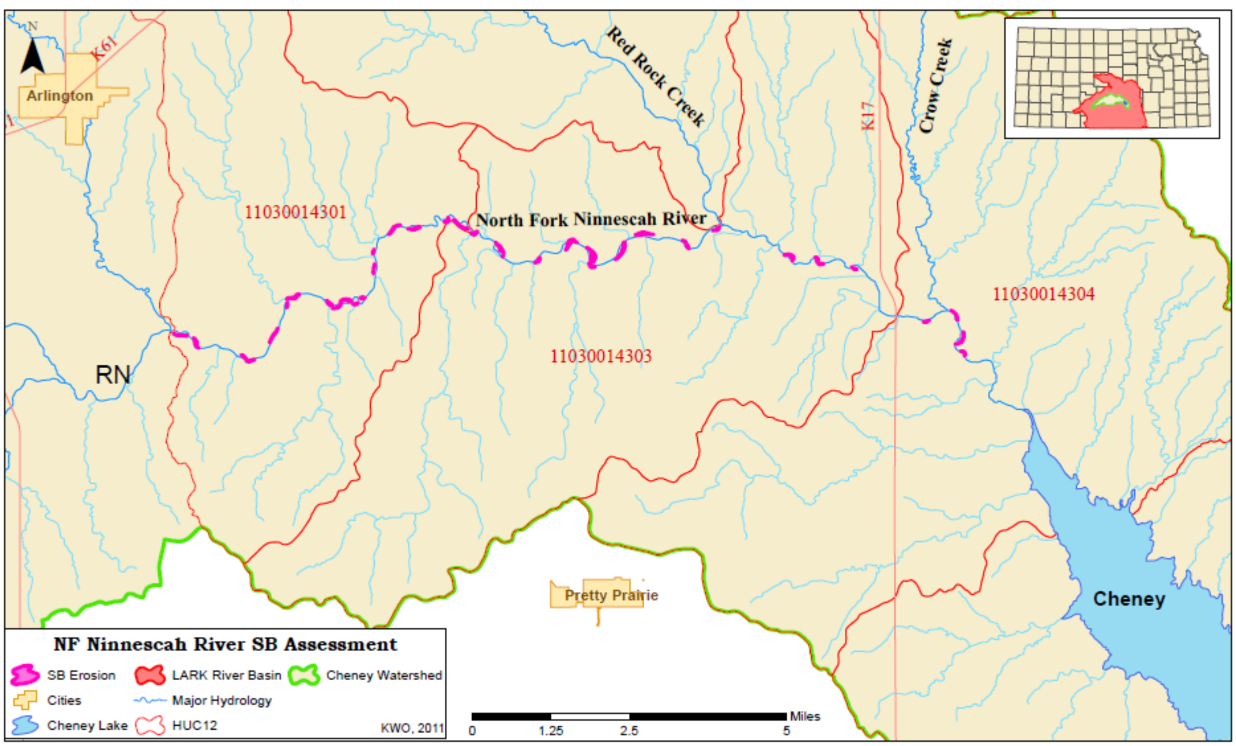


**Figure 7: TWI Estimated Costs to Implement Streambank Stabilization BMPs**

| BMP Cost Description | Cost estimate per linear foot (in dollars) |
|---|---|
| 1. Survey and design<br>Rock delivery and placement<br>As-built certification design<br>Bank Shaping | \$50 - \$75 |
| 2. Vegetation (material and planting)<br>Cover Crop<br>Mulch<br>Willow Stakes<br>Bare root seedlings<br>Grass filter strip | \$5 |
| 3. Contingencies<br>Unexpected site conditions requiring extra materials and construction time | \$3 - \$5.5 |
| TOTAL | \$58-\$85.5 |

### Results

The KWO 2011 assessment quantifies annual tons of sedimentation from streambank erosion sites between 1991 and 2008 on the mainstem North Fork Ninnescah River within the Cheney Lake Watershed. A total of 41 streambank erosion sites, covering 35,336 feet of unstable streambank were identified, with 87 percent of the identified streambank erosion sites having poor riparian condition. Sediment transport from identified streambank erosion sites accounted for 34,740 tons of sediment per year transported from the mainstem North Fork Ninnescah River downstream and possibly accumulating into Cheney Lake annually. If all sediment accounted for were to end up into Cheney Lake, it would account for 35 acre-feet per year of sediment accumulation in Cheney Lake.

A majority of the identified eroded sediment, transported annually from the mainstem North Fork Ninnescah River, was found to be coming from the North Fork Ninnescah River reach two (NFN2), at roughly 17,927 tons of sediment annually; and the North Fork Ninnescah reach three (NFN3), at roughly 7,640 tons of sediment annually (Table 1 & Figure 8). These identified reaches account for approximately 74 percent (\$1.5 million) of the total stabilization cost estimate needs for the mainstem North Fork Ninnescah River study area. Results by HUC12 identified 11030014303 (HUC12 (303)) as the having the highest amount of estimated streambank sedimentation, accounting for approximately 20,897 tons of sediment per year, with 14,960 ft of unstable streambank (Table 2 & Figure 9). HUC12 (303) also accounted for roughly 42 percent of the identified unstable streambanks, 60 percent of sedimentation and 42 percent of total stabilization costs for the study area. The total stabilization cost estimated for the mainstem North Fork Ninnescah River by conducting streambank stabilization practices for all identified sites would cost approximately \$2.5 million. Stabilization cost estimates were based on the average stabilization costs, at \$71.50 per linear foot, as reported in the TWI *Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment*.

Additional concerns observed on the Mainstem North Fork Ninnescah River visual assessment include rangeland gullies, stream meandering and poor riparian conditions. As stated above, poor riparian conditions include riparian areas consisting of rangelands, buffers or croplands. During the visual assessment, rangeland gully erosion was found in the subwatershed surrounding Crow Creek and within one mile of the mainstem North Fork Ninnescah and related tributaries extending to the Silver Creek/North Fork Ninnescah River fork. Stream meandering was observed in the subwatershed surrounding Goose Creek and at the Silver Creek/North Fork Ninnescah River fork continuing upstream on the North Fork Ninnescah River and Silver Creek. Figure 10 illustrates an example of channel meandering. The two photos are aerial photographs from the 1991 DASC database and 2008 NAIP database of the North Fork Ninnescah River Channel. The red line drawn on top of the photos, trace the 1991 North Fork Ninnescah River channel starting at the North Fork Ninnescah River/Silver Creek fork and heading upstream. The high erodibility of the Kanza-Ninnescah sandy soils found throughout the Cheney Lake Watershed and specifically along the North Fork Ninnescah River, increases the time frame at which meandering occurs naturally, causing sediment to be transported downstream. This ArcGIS® Comparison Study assessment also has a high margin of error when estimating tons of soil eroding from streambanks caused by meandering. This margin of error limited the ability to extend the assessment outside of the mainstem North Fork Ninnescah River and upstream past the Silver Creek/North Fork Ninnescah River fork.

**Table 1: Mainstem North Fork Ninnescah River Streambank Erosion Assessment Table by Stream Reach**

| Stream Reach | SB Length (ft) | SB Site Sed (T/Yr) | Stabil. Cost Estimate | SB Erosion Sites (No.) | Yield Loss/ Bank Length | Poor Riparian Cond/SB Length (ft) | Est. Sed Reduction (T/Yr) | % SB Length w/ Poor Riparian Cond. |
|---|---|---|---|---|---|---|---|---|
| **NFN1** | 6891 | 5184 | $492,758 | 9 | 0.8 | 5753.61 | 4,406.99 | 83.49% |
| **NFN2** | 11862 | 17927 | $848,162 | 11 | 1.5 | 9352.07 | 15,238.31 | 78.84% |
| **NFN3** | 9429 | 7640 | $674,176 | 13 | 0.8 | 7522.67 | 6,494.45 | 79.78% |
| **NFN4** | 7152 | 3987 | $511,433 | 8 | 0.6 | 6583.84 | 3,389.62 | 92.04% |
| | | | | | | | | |
| **Total** | **35,336** | **34,740** | **$2,526,530** | **41** | **3.6** | **29,212** | **-29,529** | **82.67%** |
| Est Stabilization Cost/Linear Ft. | | | $71.50 | **Stabilization/Restoration Efficiency** | | | 0.85 | |

**Figure 8: Mainstem North Fork Ninnescah River Streambank Erosion Assessment Graph by Stream Reach**

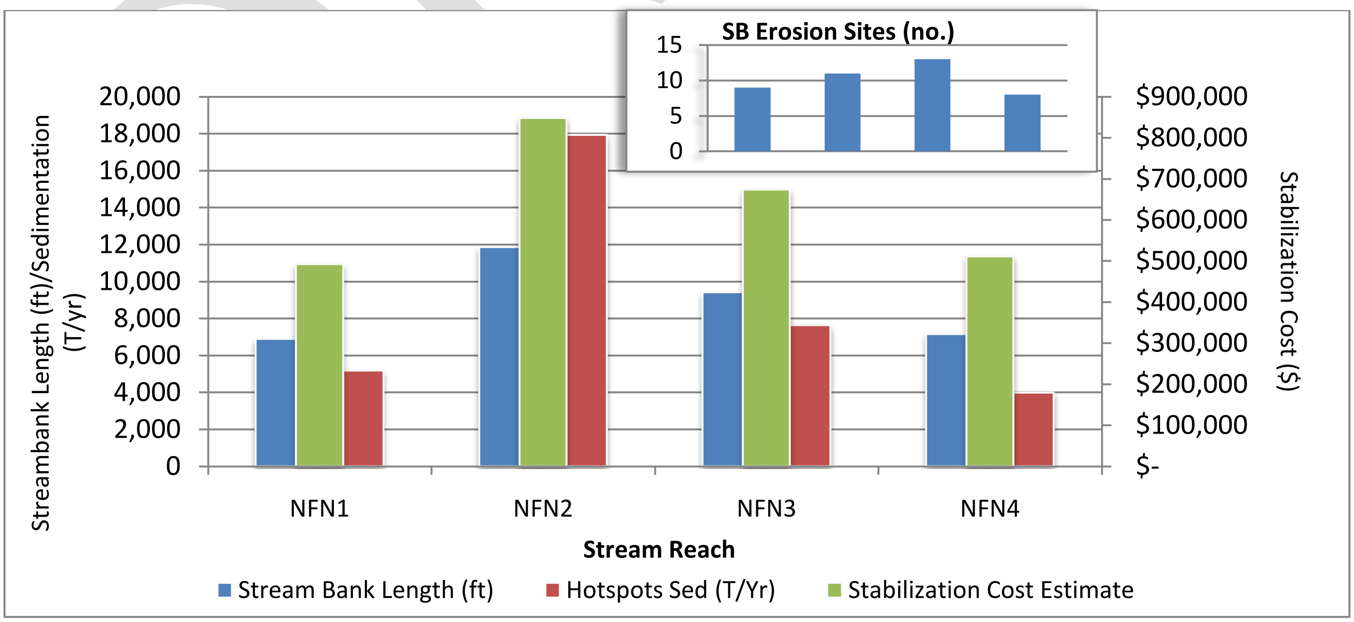


**Table 2: Mainstem North Fork Ninnescah River Streambank Erosion Assessment Table by HUC12**

| Reach HUC12 (11030014...) | SB Length (ft) | SB Site Sed (T/Yr) | Stabil. Cost Estimate | SB Erosion Sites (no.) | Yield Loss/ Bank Length | Poor Riparian Cond/SB Length (ft) | Est. Sed Reduction (T/Yr) | % SB Length w/ Poor Riparian Cond. |
|---|---|---|---|---|---|---|---|---|
| **HUC(304)** | 3,794 | 22,15 | $271,270 | 4 | 0.6 | 3120 | 1883 | 82.23% |
| **HUC(303)** | 14,960 | 20,897 | $1,069,650 | 16 | 1.4 | 11986 | 17763 | 80.12% |
| **HUC(301)** | 16,582 | 11,628 | $1,185,609 | 21 | 0.7 | 15583 | 9884 | 93.98% |
| | | | | | | | | |
| **Total** | **35,336** | **34,740** | **$2,526,530** | **41** | **2.7** | **30,689** | **-617,082,421** | **86.85%** |
| **Est Stabilization Cost/Linear Ft.** | | | $71.50 | **Stabilization/Restoration Efficiency** | | | 0.85 | |

**Figure 9: Mainstem North Fork Ninnescah River Streambank Erosion Assessment Graph by HUC12**

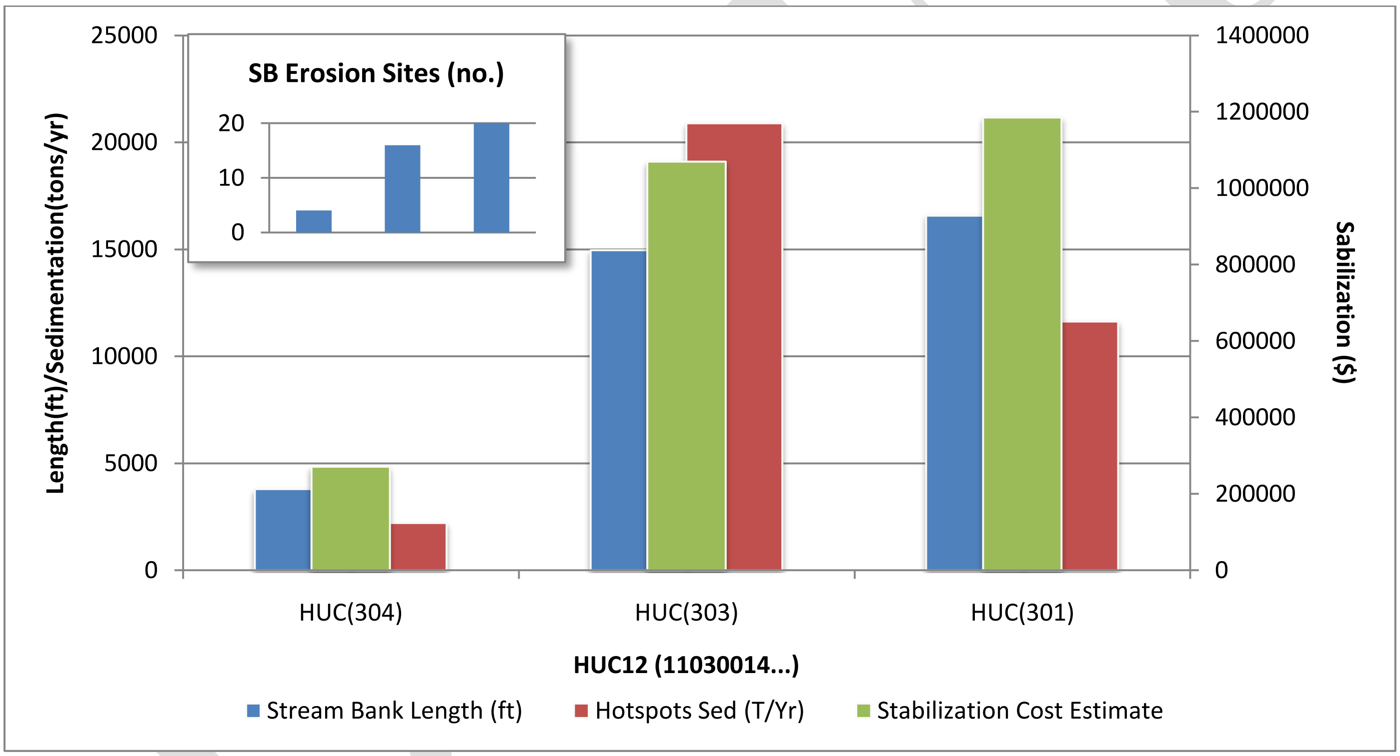
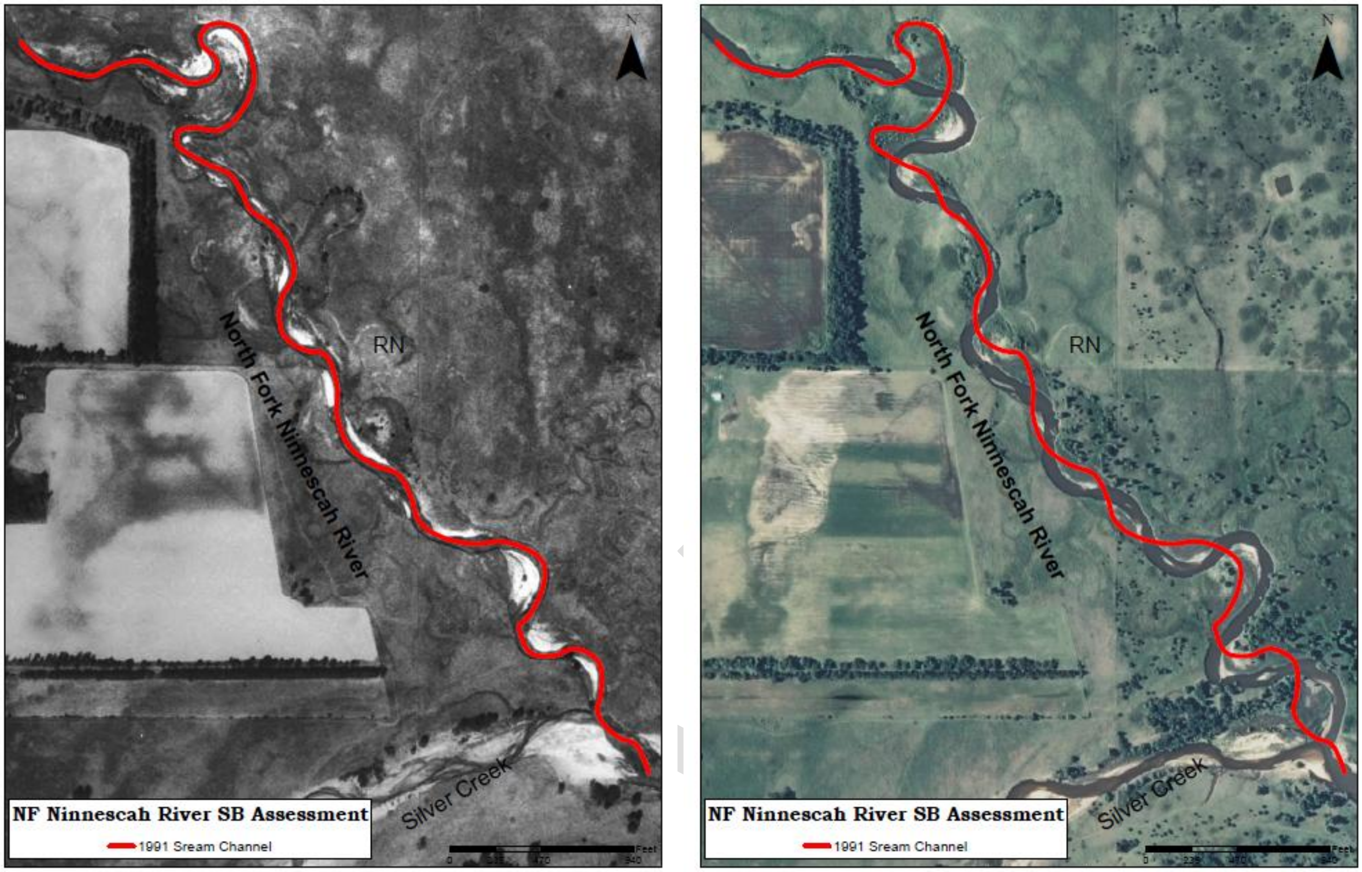


**Figure 10: 1991 North Fork Ninnescah River Channel: 1991 DASC and 2008 NAIP Aerial Photos**




## Conclusion

The KWO completed this assessment for the Cheney Lake Watershed Restoration and Protection Strategy (WRAPS) Stakeholder Leadership Team (SLT). The Draft and Final report will be submitted for internal review at KWO. After internal review, the Draft and Final Report will be submitted to the Cheney Lake WRAPS SLT. Information contained in the assessment can be used by the Cheney Lake WRAPS SLT to target streambank stabilization and riparian restoration efforts toward high priority stream reaches on the mainstem North Fork Ninnescah River within Cheney Lake Watershed.

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